OBJECTIVES

A Explain the changes in *P* and *S* wave velocities inside Earth.

B Locate the Mohorovicic discontinuity and explain how it was discovered.

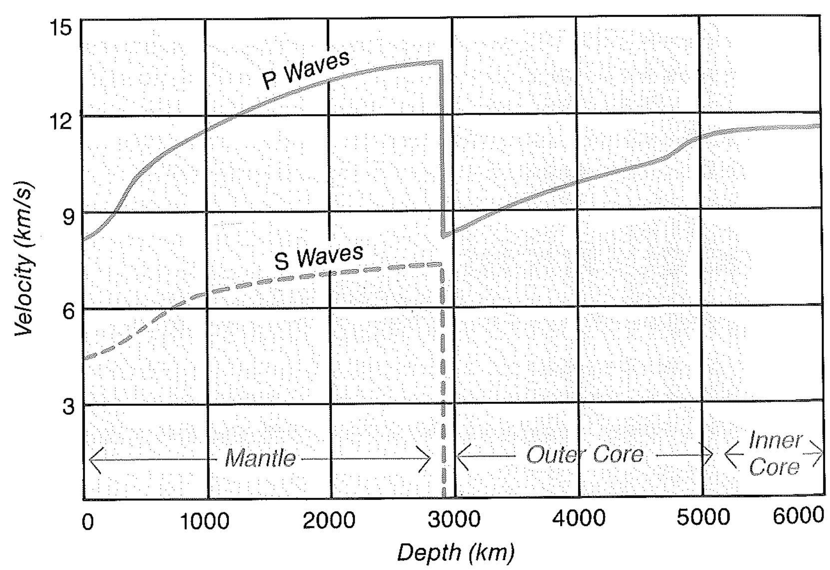
C Describe the shadow zone and explain its significance.

IV Earthquake Waves inside Earth

Topic 11 *P* and *S* Wave Velocities

Most information about the inside of Earth has come from an analysis of seismogram tracings. These tracings record far more than just the arrival times of the *P*, *S*, and *L* waves. In combination with a time-travel graph (Topic 6), the tracings can be used to determine if a wave has been bent, speeded up, slowed down, or reflected as it traveled through the inside of Earth. From these kinds of data, seismologists have been able to determine the velocities of *P* and *S* waves as they travel through the different layers inside Earth and to define the locations and characteristics of those layers.

A graph of *P* and *S* wave velocities shows the result (Figure 15.9). The most obvious feature of the graph is the sharp change in velocities at a depth of 2900 kilometers. *P* waves are greatly slowed there, and *S* waves are stopped. Since *S* waves do not pass through liquids, the material directly below 2900 kilometers must be liquid. In fact, this is the evidence that was used to show that Earth's outer core is liquid. The partial recovery of the *P* wave velocity at 5200 kilometers suggests that the inner core, like the mantle, is a solid.



15.9 This graph shows that at a depth of 2900 kilometers the *P* waves slow down and the *S* waves stop. Geologists consider that depth to be the boundary between the mantle and the liquid outer core.

Topic 12 The Moho

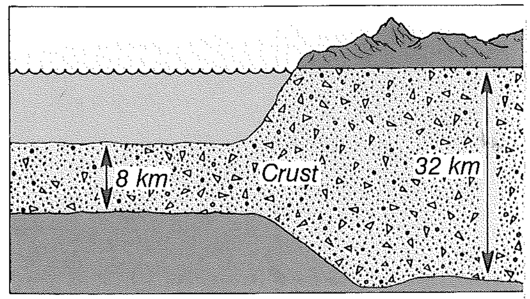
Another abrupt change in *P* and *S* wave velocities occurs at the boundary between the crust and the mantle. This change was discovered in 1909 by the Yugoslav seismologist Andrija Mohorovicic from a study of many seismograms of minor earthquakes.

Several of the seismograms showed two distinct groups of *P* and *S* waves. One of the groups had traveled at an average velocity of 7 kilometers per second, but the other had speeded up to 8 kilometers per second. Mohorovicic reasoned that the second group had gone through denser material below the crust. He calculated the depth to the denser material to be about 50 kilometers.

The boundary he discovered is considered to be the boundary between the crust and the mantle. In his honor, the boundary is named the **Mohorovicic discontinuity**, or **Moho** for short.

The Moho, however, is not at a depth of 50 kilometers everywhere. The Moho averages 32 kilometers under the continents but only 8 kilometers under the oceans. Thus the continents stand higher on the crust but also sink deeper into the mantle.

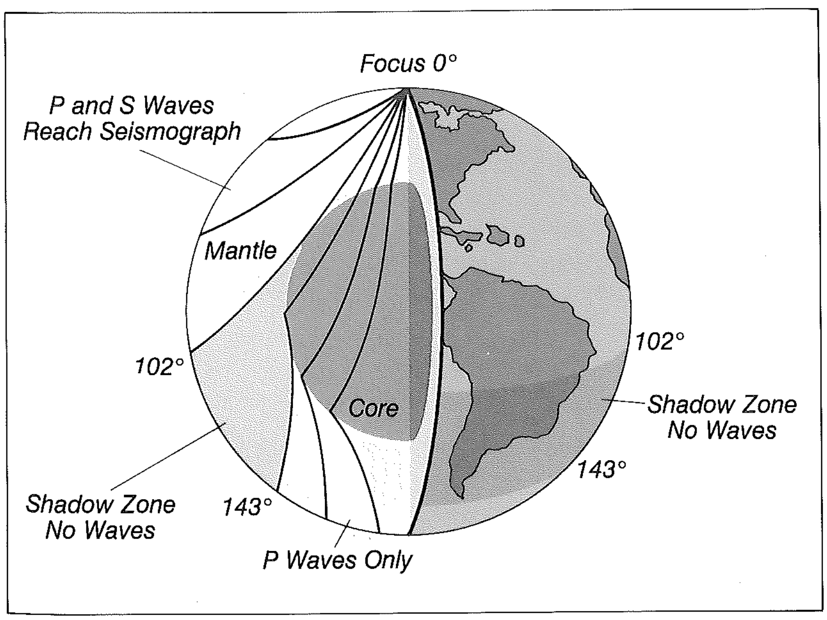
15.10 The Moho is deeper under the continents than under the oceans.



Topic 13 The Shadow Zone

Even though an earthquake sends waves throughout all of Earth's interior, not all seismograph stations receive information from all earthquakes. Some receive only *P* waves, while others receive no signal at all.

Seismic stations that receive neither *P* nor *S* waves are said to be in the **shadow zone** of that earthquake (Figure 15.11). The shadow zone is a wide belt around Earth on the side opposite the focus of the earthquake. The cause of the shadow zone is Earth's outer core. *P* waves passing through the mantle are refracted (bent) in a smooth arc back to the surface. However, a *P* wave that travels deep enough to enter the outer core is refracted twice, once when it enters the outer core and again when it leaves. The result is that a broad belt around Earth, the shadow zone, receives no *P* wave information. No



15.11 The shadow zone is caused by Earth's outer core. *S* waves do not reach the shadow zone because they are unable to penetrate the outer core. *P* waves are able to penetrate the outer core, but they are refracted so that none reach the shadow zone.

S wave information arrives in the shadow zone either. *S* waves cannot pass through liquids, and the outer core is a liquid.

Seismograph stations that are between the earthquake epicenter and the shadow zone receive both *P* and *S* waves. Stations within the shadow zone receive neither *P* nor *S* waves. Stations that are beyond the shadow zone on the opposite side of Earth from the earthquake receive only *P* waves. The *S* waves are stopped by the liquid outer core.

TOPIC QUESTIONS

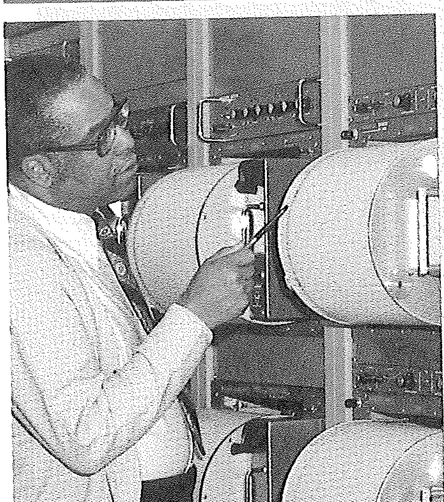
Each topic question refers to the topic of the same number.

11. **(a)** What happens to *P* wave velocities at a depth of 2900 kilometers inside Earth? **(b)** What happens to *S* waves at that depth? Why?

12. **(a)** What is the Moho? **(b)** How did Mohorovicic discover the Moho? **(c)** How does the Moho's depth vary under the continents as compared with its depth under the oceans?

13. **(a)** What is the shadow zone? **(b)** What is the cause of the shadow zone? **(c)** Why do *S* waves not come to the surface beyond the shadow zone?

CAREERS



Dr. Waverly Person
Seismologist

The National Earthquake Information Service (NEIS) in Golden, Colorado, is the most important collector of earthquake information in the world. Dr. Waverly Person is a seismologist there. He says that NEIS regularly computes magnitudes and epicenter locations for between 13 000 and 16 000 earthquakes each year.

The data that Dr. Person and other seismologists use in their work arrive in Golden by satellite transmission, telephone, telegraph, and even by letter. Much of the data arrives as real-time seismic signals sent via satellite from seismic stations throughout the United States, Canada, and other parts of the world. As the data are received, they are recorded on seismograph drums at NEIS.

When large or damaging earthquakes occur, the normal routine of epicenter analysis is interrupted in order to quickly determine the location of the earthquake. This makes it possible to alert agencies responsible for disaster relief, who are then able to begin sending help and supplies. Dr. Person says that for major U.S. earthquakes, the whole staff goes to work, no matter what the hour of the day or night.